THE EXTINCTION OF MALTA FEVER.[1]

THE subject of this evening's discourse is the extinction of Malta fever, and I propose to bring before you in this paper the various steps in the investigation of this disease which led up to the discovery of its mode of spread, and so to its prevention and extinction.

HISTORICAL.

This fever has been studied in various ways for the last quarter of a century, but it was not until 1904 that the Government, alarmed by the great wastage in man caused by it, took the matter up seriously, and asked the Royal Society to undertake a thorough investigation of the disease. This the Royal Society agreed to do, and early in the summer of the same year sent out to Malta a small Commission for this purpose; and it is principally the result of the work of the Commission which I have the honour of bringing before you this evening.

It seems a pity that this research was not undertaken twenty years earlier, as during this time some 14,000 or 15,000 sailors and soldiers have suffered from the disease. It is to be hoped that the result of this work will bring home to the Government the great good to be gained by introducing scientific methods of research into the study of disease in the Army. This, strange as it may seem, has not yet come home to Government departments. If an application was made to the Treasury to-morrow for, say, 100*l*. for such scientific purposes, the answer would be that it was not the function of the Royal Army Medical Corps to engage in scientific research, but that their duty was to attend to the sick soldiers. This waiting until a man is sick is fatal. It ought to be our chief duty to anticipate and prevent sickness.

Before I leave the subject of the Commission, I may remark that its work went on for three years before the successful result was attained.

But now to return to Malta fever.

DESCRIPTION OF MALTA FEVER.

At the outset it will be necessary to give a short description of this fever, in order that you may know what we are dealing with.

Malta fever is no trivial complaint, but is a severe and dangerous disease, which lasts a long time, and is accompanied by a good deal of pain. To give you an idea of the long duration of this fever, I may tell you that our soldiers remain under treatment in hospital with it on an average for 120 days, and it is by no means uncommon for a patient to suffer almost continually from it for two or even more years.

During the whole course of his illness the patient is apt to suffer from severe rheumatic pains in the joints, and neuralgia in various nerves, and this, combined with the long-continued fever, brings about a condition of extreme emaciation and weakness, from which recovery is slow.

In order to show you to what a degree of emaciation a few weeks of this fever may bring a man, I will take the liberty of throwing on the screen a photograph of a soldier who has been suffering from it for a few weeks. (Here a picture of a man extremely thin and evidently very ill was thrown on the screen.)

On admission to hospital this man was a robust and muscular soldier, and now see what a few weeks have brought him to.

INCIDENCE OF MALTA FEVER IN THE GARRISON.

Next I would direct your attention to the number of cases of this fever which occur among our sailors and soldiers in Malta, in order to impress upon you the importance of this disease to the State. Among our soldiers, who number about 7000, there have been on an average 312 admissions to hospital every year from Malta fever alone, and among the sailors about the same number. This means that 624 soldiers and sailors have been treated in hospital 120 days each, which makes about 75,000 days of illness per annum.

To illustrate this I throw on the screen a diagram (Fig. 1).

Now I have said enough to show you that we are dealing with a severe and important form of disease.

STUDY OF MALTA FEVER FROM THE EPIDEMIOLOGICAL POINT OF VIEW.

Before we begin the experimental investigation of this fever, it is well that we should know as much as possible about it from a general point of view. For example, in what parts of the world is it found; under what conditions of climate; whether any connection can be made out between it and the temperature or rainfall; whether age or sex render a person more liable; whether occupation or social position has any bearing on it; whether a difference in sanitary conditions has any effect, as, for example, do people living in small villages without any proper system of water supply suffer more than those living in towns supplied with pure water and a modern drainage system?

Now it is clearly impossible for me to go into all these points with the time at my disposal, but I would like to bring before you a few facts which bear on the problem we have before us.

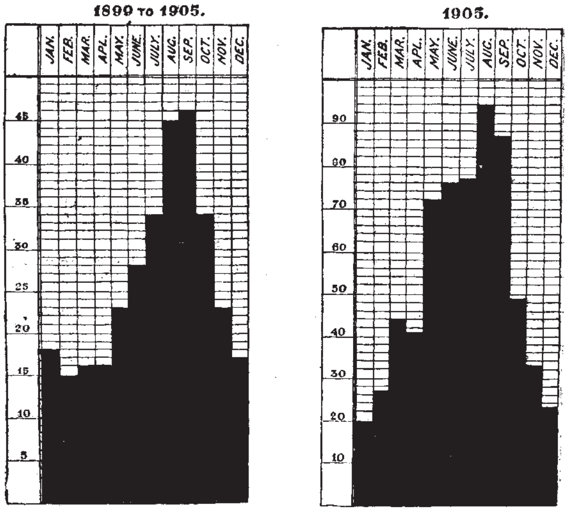

FIG. 1.—Charts of incidence in 1899–1905, and 1905.

Geographical Distribution.—For example, it is interesting to know that Malta fever is not confined to Malta, but occurs in most parts of the world.

Climatic Conditions.—Then again in regard to the effect of climate. Malta is extremely hot and dusty in the summer, and correspondingly cold and wet in winter. But, although the number of cases of Malta fever do show an increase in summer, yet it is a disease which is prevalent all the year round, one-third as many cases occurring in the coldest and rainiest months as in the hottest and dustiest.

Another fact of importance is that if we study the occurrence of Malta fever in individual years we are struck by its irregularity, a number of cases appearing in December or February or other of the cold and rainy months.

Social Position.—Another curious fact in regard to this disease is that the better the social position of a person the more risk is there of catching this fever. Officers and their wives and children, living in large, airy, and clean houses, suffer more frequently than the men in their more crowded barrack-rooms. In fact, the chance of a naval or military officer taking this fever was more than three times as great as in the case of the men.

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[1] Discourse delivered at the Royal Institution on Friday, January 24, by Colonel David Bruce, C.B., F.R.S.

This is shown on this diagram (Fig. 2).

Distribution of Malta Fever among the Civil Population.—Another important fact is the distribution of Malta fever among the civil population. Until recently it was supposed by many of us that it was restricted to the inhabitants of the cities surrounding the Grand Harbour. This was in the days when the theory was held that the poison which causes this fever was found in the air. As the Grand Harbour at that time was in a very dirty condition, the drainage of Valletta and the three cities falling into it, there was some excuse for this belief.

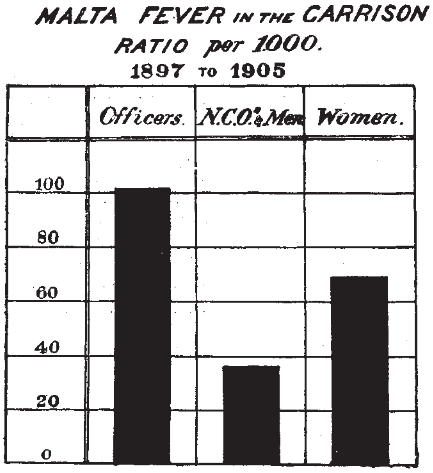


FIG. 2.—Incidence in officers, men, and women for 1897-1905.

Malta fever is now known to occur in every part of the island, and, in fact, the general distribution of this disease is very striking. It is not the cities round the Harbour which are struck most heavily, some of the inland towns and villages showing a much higher fever-rate.

This is illustrated by the following diagram (Fig. 3).

SUMMARY OF EPIDEMIOLOGICAL EVIDENCE.

What, then, have we learned from the study of this fever from the general point of view?

We have found that Malta fever depends on no local conditions, as it occurs in many parts of the world. It cannot have any great dependence on climatic conditions, as it occurs in the cool and rainy months almost as frequently as in the hot, dusty, and rainless.

Poverty and insanitary surroundings do not predispose; in fact, the well-to-do classes have been shown to be more liable to take the fever than the poor. It has no connection with water supply or systems of drainage, as it breaks out as frequently in the smallest country villages as in the large cities.

What, then, is the cause of this fever?

STUDY OF MALTA FEVER BY THE EXPERIMENTAL METHOD.

Discovery of the Parasite.—Let us approach this problem from the experimental side. The first step to be taken is to discover if any parasite or micro-organism is associated with this fever. To do this we examine the blood and the tissues of the various organs, both microscopically and by means of cultivation, on suitable media, to find out if anything can be seen or grown. In this way, as long ago as 1887, it was discovered by an army medical officer that a minute organism, to which the name of *Micrococcus melitensis* was given, is the cause of this disease.

Description of the Micrococcus melitensis.—There is not much to be said about this micro-organism, except that it is very minute, only becoming visible under a magnification of 1000 diameters. It is round or oval in shape, and non-motile. It is found in every case of Malta fever, and if injected under the skin of monkeys gives rise in them to a fever similar to that in man.

CHARACTERISTICS OF THE *Micrococcus melitensis.*

Behaviour outside the Body.—Now, having found the micro-organism, it is necessary to study its characteristics.

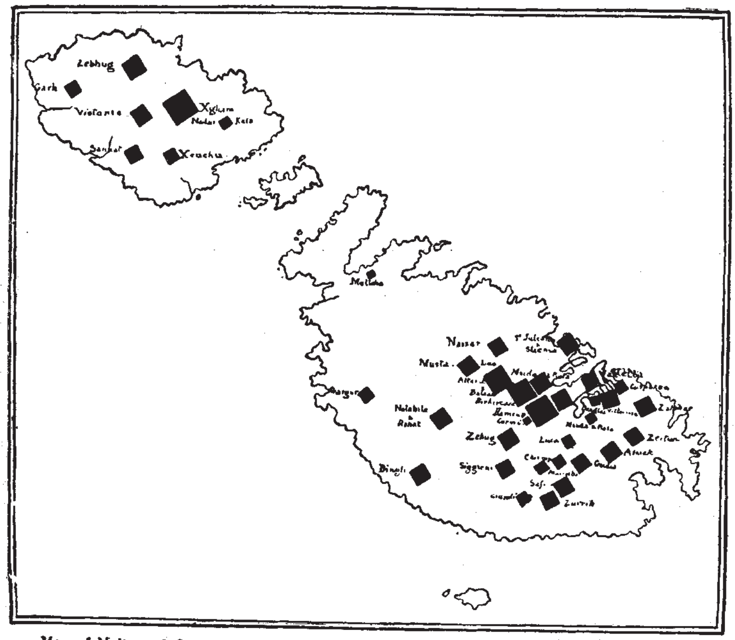
It is found to survive outside the body for some time. For example, it can retain its vitality and virulence in a dry condition in dust or on clothing for at least two or three months. It can also live in a moist condition; in water—tap-water or sea-water—for a somewhat shorter period.

The important thing to be noted is that it does not increase outside the body; it merely survives for some time and then dies off, and, if exposed to direct sunlight, it disappears in a few hours.

Many attempts were made to discover it outside the body under natural conditions. As the generally accepted theory was that it was conveyed in air, naturally the air of fever wards or of places where cases had occurred was examined with great care. It was also looked for in the dust of suspected places and in the water of the Harbour, but with no success. It is evidently what is known as a facultative parasite, or one which depends on a host for its existence.

Thus, then, the first important step in our discovery of a means of preventing Malta fever has been taken. We now know the cause of the disease, and can look with some chance of success for the source whence man obtains it.

The next steps are to find out how this micrococcus leaves and how it gains entrance to the body.



Map of Malta and Gozo, showing the Distribution of Malta Fever in the various Towns and Villages of the two Islands

FIG. 3.—Incidence in civil population.

HOW DOES THE *Micrococcus melitensis* LEAVE THE BODY?

In regard to the first of these, it is conceivable that it might leave the body by way of the expired air, in the saliva, in mucus from the lungs, as in consumption, in the secretion of the skin, as in scarlet fever, in the renal secretion, or by way of the intestinal tract. Or it might leave the body by way of the blood, by the agency of mosquitoes or other biting flies.

Many experiments were made along all these lines, and finally it was decided that this micro-organism leaves the body principally in the renal secretion, and in the blood taken out of the body by blood-sucking insects.

The result, therefore, of this experimental work was to give rise to the belief that the disease was either conveyed from the sick to the healthy by contact, by inhalation of infected dust, or, lastly, by the agency of mosquitoes.

HOW DOES THE *Micrococcus melitensis* GAIN ENTRANCE TO THE BODY?

The investigation of these various modes of infection was therefore undertaken.

By Contact.—Let me first consider infection by contact. Experiments were made by placing monkeys, one affected by Malta fever, the other healthy, in more or less intimate contact, and it was found that if the monkeys lived together in the same cage infection did take place. If, on the other hand, the monkeys were kept in the same cage, but separated by a wire screen, so that, although they could touch each other, contamination of the healthy monkey's food by the sick monkey could not take place, then infection did not take place.

In regard to this question of conveyance by contact, there is one argument against it which has always seemed to me unanswerable, and that is that thousands of cases of Malta fever have been invalided home to England, and treated in our naval and military hospitals, without, as far as I am aware, a single case of the fever arising among the patients, orderlies, or nursing sisters.

It was therefore concluded that contact with Malta fever patients, or the handling of infected clothing or discharges, is not the mode of infection.

Then the question of infection by contaminated dust was taken up.

By Dust contaminated by the Micrococcus melitensis.—For some time it was considered probable that this would prove to be the common method of infection. The fact that the micrococcus withstands drying for a long time, the dusty nature of Malta, and the probability that gross contamination of the surface of the soil takes place by infective discharges, rendered this view likely.

Experiments were made to put the theory to the test. Dust was artificially contaminated with micrococci and blown about a room in which monkeys were confined, or blown into their nostrils or throat. Several of these experiments were successful. It was therefore proved that dust *artificially* contamined with *Micrococcus melitensis* could give rise to the disease.

This, however, was no proof that this mode of infection occurs in Nature. The artificially-contaminated dust contained myriads of micrococci. Under natural conditions they could seldom be numerous, and the powerful Maltese sunlight would tend to kill them off rapidly. The dust blown about by the wind must also dilute the micrococci to an enormous extent, so that it is only possible to conceive of a micrococcus here and there in a vast quantity of dust. Experiments were therefore made with dust naturally contaminated, in order more closely to resemble natural conditions. Dust contaminated in this way, and also that collected from suspicious places, and blown about the cages, sprinkled on food, or injected under the skin, always gave negative results.

The conclusion was therefore again come to that conveyance of the infective germ by means of contaminated dust could only rarely, if ever, give rise to the disease.

By Mosquitoes or other Biting Insects.—As already mentioned, the theory had been strongly advanced that Malta fever, like yellow fever or plague, might be conveyed by blood-sucking insects. The fact that the micrococci are frequently found in the peripheral blood gave some colour to the belief. This point was therefore fully investigated, and numerous experiments made with the different species of mosquitoes found in Malta, and also with other blood-sucking insects.

The results, again, were all negative, and it was therefore decided that Malta fever is not conveyed by contact, by contaminated dust, or by mosquitoes.

What, then, could be the mode of spread?

By Way of the Alimentary Canal.—It had long been known that the smallest quantity of the micrococci introduced under the skin or applied to a scratch would give rise to the disease in man or monkeys, but some work by previous observers had led us to believe that infection did not take place by way of the mouth in food or drink. They had fed monkeys on milk contaminated by the micrococci, and stated that in no case had infection taken place. This observation kept the Commission at first from making feeding experiments. As infection, however, did not appear to take place by contact, by the inhalation of infected dust, or by mosquitoes, it was clearly necessary to repeat these feeding experiments.

FEEDING EXPERIMENTS.

Here is a table showing the result of some of these feeding experiments, and you see it is abundantly proved that Malta fever can be conveyed to healthy animals by way of the alimentary canal. Even a single drink of a fluid containing few micrococci almost certainly gives rise to the disease (Fig. 4).

Malta Fever

Species of animal	Mode of infection. M. = *M. melitensis*	Probable time which elapsed before infection took place in days	Result. + Infection − No infection
Monkey 39	Feeding on potato containing M.	30	+
,, 40	Do. do.	31	+
,, 66	Accidental feeding ..	..	+
,, 72	Milk + M.; stomach tube	.	+
,, 113	Dust + Mediterranean fever urine. Dried		−
,, 114	Do. do.	..	−
,, 119	Dust + Mediterranean fever urine. Moist	.	+
,, 124	Potato + M. from spleen	..	+
,, 125	Do. do.	..	+
,, 126	Potato + M. from urine	..	+
,, 127	Do. do.	..	+
,, 2	Milk + M.	..	+
,, 4	Do.	..	+
,, 5	Do.	..	+
,, 99	Do.	..	+
,, 6	Culture	..	+
,, 7	Do.	..	+
,, 8	Do.	..	+
,, 9	Do.	..	+
,, 19	Do.	18	+
,, 19a	Do.	32	+
Kid 9	Milk	..	−
,, 19a	Mother's milk ..	..	−
Goat 12	Culture from milk ..	..	+
,, 13	Mediterranean fever urine and dust	..	+
14	Do. do.	..	+
,, 4	Milk + culture ..	..	+

FIG. 4.—Feeding experiments.

From the results, then, of all these experiments it seemed most probable that the micrococcus gained an entrance to the body by way of the alimentary canal, and therefore by some infected food or drink.

FIG. 5.—Milking goat.

This led to an examination of food-stuffs, and among these the milk of the goat is one of the most important.

INFECTION BY MEANS OF GOATS' MILK.

The goat is very much in evidence in Malta, and supplies practically all the milk used. There is, I believe, one goat to every ten of the population, so that, as there are 200,000 inhabitants, there must be 20,000 goats. Flocks of them wander about the streets from morning until night, and are milked as required at the customers' doors (Fig. 5).

It must be confessed there seemed little hope that an examination of these animals would yield any result. The goats appeared perfectly healthy, and they have the reputation of being little susceptible to disease of any kind.

To put the matter to the test several goats were inoculated with the micrococcus, and the result watched. There was no rise of temperature, no sign of ill-health in any way, but in a week or two the blood was found to be capable of agglutinating the specific micro-organism.

This raised our suspicions, and a small herd of apparently healthy goats was then procured and their blood examined to see if they were all healthy. Several of them were found to react naturally to the agglutination test, and this led to the examination and the discovery of the *Micrococcus melitensis* in their blood, urine, and milk.

MICROCOCCI IN GOATS' MILK.

Some thousands of goats in Malta were then examined, and the astounding discovery was made that 50 per cent. of the goats responded to the agglutination test, and that actually 10 per cent. of them were secreting and excreting the micrococci in their milk.

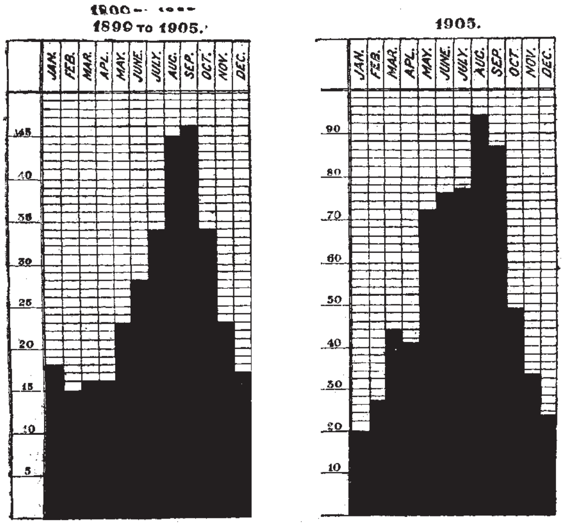


FIG. 6.—Charts of incidence among the soldiers in 1899–1905, and 1905.

Monkeys fed on milk from an affected goat, even for one day, almost invariably took the disease.

S.S. *Joshua Nicholson*

At this time, curiously enough, an important experiment on the drinking of goats' milk by man took place accidentally. Shortly, the story is as follows:—In 1905 the s.s. *Joshua Nicholson* shipped sixty-five goats at Malta for export to America. The milk was drunk in large quantities by the captain and the crew, with the result that practically everyone who drank the milk was struck down by Malta fever.

Sixty of the goats (five having died) on arrival in America were examined, and thirty-two found to give the agglutination reaction, while the *Micrococcus melitensis* was isolated from the milk of several of them. This epidemic of Malta fever on board the s.s. *Joshua Nicholson* therefore clinched the fact that the goats of Malta act as a reservoir of the virus of Malta fever, and that man is infected by drinking the milk of these animals.

EPIDEMIOLOGICAL FEATURES.

Here, then, at last was discovered a mode of infection which explains the curious features of Malta fever—the irregular seasonal prevalence, the number of cases which occur during the winter months, when there are no mosquitoes and little dust. It is true there are more cases in summer than in winter, but this may be explained by the fact that more milk is used at that time of the year for fruit, in ice-creams, &c. It also explains the fact that officers are more liable than the men, as the former consume more milk than the latter. It also explains the liability of hospital patients, milk entering so largely into a hospital dietary.

RESULT OF MEASURES DIRECTED AGAINST THE USE OF GOATS' MILK.

As soon as goats' milk was discovered to be the source of infection, preventive measures were begun. The result is very striking, as is shown in the charts thrown on the screen, which give the number of cases of Malta fever among the soldiers in the garrison before and after the preventive measures came into action.

Here is a chart of the incidence of Malta fever among the soldiers each month before the preventive measures were put into force (Fig. 6).

And here is another showing the incidence of this fever among the soldiers and sailors in Malta since goats' milk has been banished from their dietary (Fig. 7).

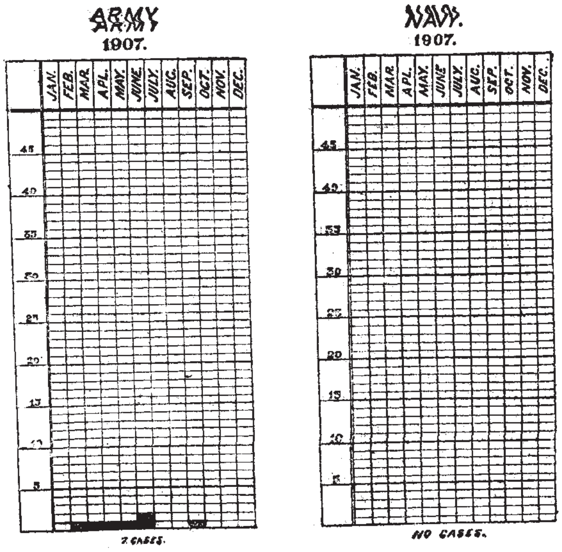


FIG. 7.—Charts of incidence among the soldiers and sailors, 1907.

With this chart, which shows the practical extinction o Malta fever, my discourse comes to a close.

RUSSIAN TRANSLITERATION.

THE system of transliteration from Russian generall adopted in British libraries and scientific bibliographies is that first published in NATURE on February 27 1890. It was the result of consultation by a committe of which the secretaries were Prof. Miers and the writer This system was intended to satisfy the need for som uniform practice, and it was based on the principle tha no system of transliteration from Russian would be suitable for bibliographic work unless every word may be re transliterated into the original Russian spelling, so that i may be found in a dictionary. It was accordingly necessary that each Russian character should have one constan equivalent, and that the equivalents should be so arrange that the same combination of letters should not resul from different Russian characters. It was also considere advisable to use accents as little as possible. Phoneti considerations and elegance in appearance were regarde as unimportant in comparison with the main requirement of certainty in re-transliteration.